Characterizing P in Wisconsin

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Characterizing phosphorus dynamics in tile-drained agricultural fields of eastern Wisconsin

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SUMMARY

Artificial subsurface drainage provides an avenue for the rapid transfer of phosphorus (P) from agricultural fields to surface waters. This is of particular interest in eastern Wisconsin, where there is a concentrated population of dairy farms and high clay content soils prone to macropore development. Through collaboration with private landowners, surface and tile drainage was measured and analyzed for dissolved reactive P (DRP) and total P (TP) losses at four field sites in eastern Wisconsin between 2005 and 2009. These sites, which received frequent manure applications, represent a range of crop management practices which include: two chisel plowed corn fields (CP1, CP2), a no-till corn–soybean field (NT), and a grazed pasture (GP). Subsurface drainage was the dominant pathway of water loss at each site accounting for 66–96% of total water discharge. Average annual flow-weighted (FW) TP concentrations were 0.88, 0.57, 0.21, and 1.32 mg L^{-1} for sites CP1, CP2, NT, and GP, respectively. Low TP concentrations at the NT site were due to tile drain interception of groundwater flow where large volumes of tile drainage water diluted the FW-TP concentrations. Subsurface pathways contributed between 17% and 41% of the TP loss across sites. On a drainage event basis, total drainage explained between 36% and 72% of the event DRP loads across CP1, CP2, and GP; there was no relationship between event drainflow and event DRP load at the NT site. Manure applications did not consistently increase P concentrations in drainflow, but annual FW-P concentrations were greater in years receiving manure applications compared to years without manure application. Based on these field measures, P losses from tile drainage must be integrated into field level P budgets and P loss calculations on heavily manured soils, while also acknowledging the unique drainage patterns observed in eastern Wisconsin.

1. Introduction

Eutrophication, the accelerated nutrient enrichment of surface waters, impairs freshwater ecosystems in Wisconsin and around the world by causing unfavorable odors, algal blooms, and fish kills. Agricultural phosphorus (P) loss is the dominant driver of accelerated eutrophication in many freshwater lakes and streams (Carpenter et al., 1998a, b; Sharpley et al., 1994). A given field's susceptibility to P loss is influenced by soil properties, landscape position, management history, and current practices. There is also a disproportionality of P loss within a watershed; it has been estimated that 80% of losses come from 20% of the watershed (Sharpley et al., 2009).

Phosphorus leaching losses have been historically discounted because orthophosphate, the biologically active form of P, rapidly adsorbs onto soil surfaces. Furthermore, recent studies have concluded that tile drains are not main contributors to watershed P fluxes (e.g. Domagalski and Johnson, 2011; Sprague and Gronberg, 2012), although results from Gentry et al. (2007) indicate that tile drainage is a major contributor in specific watersheds. It is likely that P contribution from tiles can vary on a watershed-by-watershed basis and Ulén et al. (2011) make the case for the need for tile drains to be considered in P risk assessment. Other research highlights the risk of P loss from tile drains. Algoazany et al. (2007) determined that at four out of five continuously monitored sites in Illinois, tile drains exported more P than surface

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